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PRESERVATIVE TREATMENTS AND SERVICE LIFE OF FENCE POSTS IN PUERTO RICO (1972 Progress Report)

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RESUMEN

En Puerto Rico, desde el año 1944, se han estado investigando las técnicas de preservación de postes para cercas usando los métodos sin presión más económicos. Recientemente se han establecido estudios de campo y la mayor parte de los postes instalados tienen un servicio de 12 a 13 años. Los postes tratados por cuatro métodos sin presión (remojo frío en aceite preservativo, baño caliente y frío, remojo en sales preservativas y difusión por los extremos), usando cinco agentes químicos (creosota, pentaclorofenol, carbolina, y dos combinaciones de sales en doble difusión) están ahora instalados en cuatro localidades de prueba. Alrededor de 6,700 postes tratados y sin tratar, representando 70 especies, están bajo estudio.

Este cuarto informe de progreso, que incluye todos los estudios llevados a cabo en este Instituto, describe en detalle los materiales usados, métodos de tratamiento, retenciones químicas, suelo y clima en cada parcela, y revisa la condición de los postes hasta la inspección de abril de 1972. La mayor parte de los postes ha estado en servicio por trece años, y podemos ahora llegar a las siguientes conclusiones, algunas tentativas y otras finales: 1) los postes sin tratar tienen un promedio de vida útil de 1-1/2 años; 2) durante los primeros años de exposición los postes tratados, instalados en áreas de elevaciones bajas, tienen muchas más fallas que aquéllos instalados en áreas de elevaciones altas.... según continúa su exposición, estas discrepancias se van disminuyendo; 3) aunque localmente el efecto de las termitas puede ser severo, la mayor parte de las fallas se deben a la podredumbre causada por los hongos; 4) los postes tratados por remojo frío en pentaclorofenol con aceite diesel, en posición vertical con el tope hacia abajo, absorben más solución preservativa y tienen una vida útil más larga que aquéllos remojados en posición horizontal; 5) los tratamientos de baño caliente y frío usando pentaclorofenol o creosota tienen, a esta fecha, pocas fallas pero donde se puede predecir la vida útil, ésta tiene un promedio de 16 a 18 años; 6) los postes tratados por el método de alta concentración de sales de doble difusión, aplicado por inmersión completa, son intermedios en durabilidad a aquellos tratados por el método de baño caliente y frío; 7) después de 5 años de exposición, solamente se encontró una falla entre 348 postes que se usaron en el estudio de incisión, anticipándose un promedio de vida útil de más de 20 años.

SUMMARY

Low investment non-pressure wood preservation techniques for fence posts have been under investigation in Puerto Rico since 1944. Extensive field trials, however, have been established only recently and most of the posts have been in service for 12 to 13 years. Posts treated by four non-pressure techniques (cold soaking, hot-and-cold bath, steeping, and end-diffusion) using five wood preservation chemicals (creosote, pentachlorophenol, carbolineum, and two double-diffusion salt combinations) are now set out at four test locations. About 6,700 treated and non-treated control posts representing some 70 species are under study.

This fourth comprehensive progress report describes in some detail the materials used, treating methods, chemical retentions, soil and climate at each plot, and reviews the condition of the posts through the April 1972 inspection. Most of the posts have been in service for 13 years and some tentative as well as final conclusions can now be made. They are: 1) untreated posts have an average service life of only 1.5 years; 2) during early years of exposure, treated posts at the low elevation site have many more failures than those set out in the high elevation sites... as exposure continues these differences are slight; 3) although termite attack may be locally severe, decay fungi cause most of the failures; 4) posts cold-soaked in pentachlorophenol-diesel oil in a vertical position butt down had a greater preservative solution absorption and much longer service life over those cold-soaked in a horizontal position; 5) hot-and-cold bath treatments using pentachlorophenol or creosote have, to date, few failures but where service life is predictable this averages 16-18 years; 6) posts treated with the high concentration double-diffusion salts by complete immersion are intermediate in durability to those treated by cold soaking in pentachlorophenol or creosote and those treated by the hot-and-cold bath technique; 7) after 5 years exposure, there is only 1 failure out of 348 posts set out in the incising study, an average service life of over 20 years is anticipated.

PRESERVATIVE TREATMENTS AND SERVICE LIFE OF FENCE POSTS IN
PUERTO RICO (1972 PROGRESS REPORT)

by

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INTRODUCTION

Benefits from the use of fence posts properly preserved against decay and termite activity have had little recognition in Puerto Rico. This can be attributed partially to the lack of knowledge concerning the treatability of local species using simple methods that could be readily applied by farmers, stockmen, and others.

The forest lands of Puerto Rico contain numerous species of trees in sizes suitable for fence posts and small poles. Except in a few mangrove areas, these trees are scattered over a large area with little or no concentration of any one species. Therefore, any useful evaluation of treatability and serviceability of local-grown woods must cover a large number of species. Results of such broad evaluations can lead silviculture toward the favoring of those species most suitable for preservation treatment.

At the present time there is a potential market for hundreds of thousands of treated posts per year. A small pressure plant could satisfy this need, but the high initial cost and the long-time effort required to develop consumer acceptance favor the study of low-investment non-pressure methods.

To help introduce good wood preservation practices, a demonstration test plot was first established by the Institute in 1944. Though very limited in scope, this early trial did show that long service life could be anticipated if a suitable chemical is properly applied by the hot-and-cold bath technique.

Extensive treating and evaluation trials were started in 1959-1960. Posts treated by four non-pressure techniques using five wood preservation chemical combinations are now set out at four test locations. About 6,700 treated and non-treated control posts representing some 70 species are under study. Results of some of these treatability and durability studies have been reported by Englerth (12, 13) and Englerth and Goytía (14).

An initial all-inclusive report (11) reviewed the condition of the posts up through a 1963 inspection. Later publications (8, 9) gave the results of 1967 and 1969 inspections. This present report covers these serviceability trials to April 1972. In addition there are current results of a recent installation evaluating the effect of incising on preservative absorption and service life.

¹/ In cooperation with the University of Puerto Rico

These continuing wood preservation studies are based on the efforts of several present and former staff members and the authors gratefully acknowledge their contributions. The first hot-and-cold bath tests at the Institute were made in 1944 by J. Marrero and the 1952 cold soaking trials were established by M.A. Hernández Agosto. The posts in the 1959-1960 installations, which account for most of the tests under review in this report, were treated and set out under the supervision of G.H. Englerth with the assistance of E. Goytí Olmedo. Double-diffusion results would have been of limited value without the generous cooperation and analytical work of R.H. Baechler, L.R. Gjovik, and R.F. Reinke of the Forest Products Laboratory (maintained at Madison, Wisconsin by the U.S.D.A. Forest Service in cooperation with the University of Wisconsin).

POSTS

In the comprehensive 1959 trials, 10 common Puerto Rican species were selected for cold soaking and hot-and-cold bath treatments using both pentachlorophenol and creosote. Nineteen additional species suitable for fence posts were treated with pentachlorophenol by both cold soaking and hot-and-cold bath. Twenty-six less common species were treated by cold soaking only, using pentachlorophenol. Thus, these and the other installations are representative of many of the available species growing to post size in the forests and plantations of Puerto Rico.

Most of the posts had top diameters of 2 to 3 inches, were 6 feet long, and consisted almost entirely of sapwood. A few posts included an appreciable amount of heartwood, and about 250 posts out of some 6,700 under study had other dimensions.

All of the posts were debarked before treatment and, except for the double-diffusion posts which were treated green, air-seasoned for 3 months or longer to a moisture content averaging about 18 percent. To minimize insect and fungus attack during seasoning, most of the posts were given an initial dip in a mixture of sodium pentachlorophenate and the gamma isomer of benzene hexachloride. The posts used in the 1952 installation were not given this pretreatment, and there was severe insect attack in some of the material.

The density of the posts under survey ranges from 17 to 59 pounds per cubic foot, averaging 42 pounds (based on the air-dry weight and volume at approximately 18 percent moisture content). The very low density woods (less than 25 pounds per cubic foot) are:

achiотillo ¹	tulipán africano
almácigo	yagrumo hembra
guacimilla	yagrumo macho

Extremely dense woods (about 55 pounds per cubic foot and over) under test are:

ausubo	casuarina
cacao motillo	cieneguillo
úcar	

¹/ Common and scientific names of all species mentioned are listed in the appendix.

PRESERVATIVES

Pentachlorophenol

Commercial grade pentachlorophenol concentrate was diluted in a diesel oil carrier. A 10 percent solution (by weight) was used in the cold-soak treatment of posts installed at Cambalache and Toro Negro in 1952. All other "penta" treatments used a 5 percent solution. Properties of the oil carrier were as follows:

Specific gravity (A.P.I. 60°/60°F)	32.7
Flash point (Pensky-Martens)	173°F
Viscosity (S.U.S. at 100°F)	37
Distillation:	
initial boiling point	386°F
10 pct. recovery at	466°F
50 pct. "	524°F
70 pct. "	558°F
90 pct. "	618°F
end point	620°F
total recovery	99.5 pct.

The above analysis is representative of one batch of diesel oil (No. 2-D Diesel fuel) used to make up the treating solutions and is believed to be typical of the oil solvent used throughout this study. This oil can be classified as a "Heavy Petroleum Solvent" and conforms to A.W.P.A. Standard P9-62 (1). In order to darken the oil and thus facilitate penetration measurements, 2 percent of No. 6 fuel oil was blended with the diesel oil.

Creosote

Commercial grade creosote conforming to A.W.P.A. Standard P1-54 (1) was blended with the oil described above to give a 50-50 (by volume) creosote-oil solution.

Carbolineum

The use of this preserving oil was limited to a few of the early studies. Distillation results of a carbolineum sample from the 1950 treatment were as follows:¹

Specific gravity at 38°/15.5°C	1.090
Moisture	0.1 pct.
Distilling up to 210°C	0 pct.
235°C	5.1 pct.
270°C	26.4 pct.
315°C	48.2 pct.
355°C	75.5 pct.
Residue above 355°C	24.0 pct.
Distillation loss	0.5 pct.
Total recovery	100 pct.

¹/ Analyses by R.H. Baechler, formerly of Forest Products Laboratory, Madison, Wisconsin.

Specific gravity of distillation fractions
at 38°/15.5°C:

235° - 315°C	1.0447
315° - 355°C	1.1154

Generally the effectiveness of carbolineum as a wood preservative is similar to that of the coal-tar creosotes. (15)

Double diffusion salts

In these treatments two salt combinations were used. Combination FC (fluor copper) consisted of a 4 percent solution of sodium fluoride followed by a 7 percent solution of anhydrous copper sulfate. Combination CAC (copper arsenate chrome) consisted of a 10 percent anhydrous copper sulfate solution in the first stage and a mixture of 6.5 percent anhydrous sodium chromate and 6.5 percent anhydrous sodium arsenate in the second stage. All chemicals were technical grade and dissolved in tap water to the desired concentration.

TREATMENTS

Cold soaking, hot-and-cold bath, and double diffusion (steeping and end diffusion) methods were used in the treatments, and since these techniques have been described in detail elsewhere (2, 3, 4, 5, 6), only a brief review of procedure will be given.

Cold soaking

In the 1959 installation, the length, butt and top diameters, heartwood diameters (if present), and air-dry weights of each post were determined prior to treatment. To assure that sufficient seasoning had taken place, moisture contents were checked with a moisture meter. Batches of posts were then clamped horizontally in a carrying frame and submerged for 5 to 7 days in either the 5 percent pentachlorophenol or the 50-50 creosote-fuel oil solution. At the end of the treating time, posts were removed from the tank, allowed to drain, and reweighed.

Retention in pounds per cubic foot was determined for each post using the calculated volume and the pounds of preservative solution absorbed. Five to 11 posts of each species, representing low, average, and high retentions, were then cross-sectioned at 1-foot intervals along their lengths to determine average side penetration as a percentage of the sapwood radius.

In the 1952 tests, the treating tank was two oil drums welded end to end. Posts were submerged vertically with the butt down in a 10 percent pentachlorophenol solution for a period of 5 days. Retentions were determined as described above. No measurements of penetration were made.

Hot-and-cold bath

Posts in the 1959 trials were weighed, measured, and treated in the same chemicals and concentrations as described for the 1959 cold-soak study. Posts were submerged horizontally in the preservative, maintained at about 200°F, for 2 to 15 hours and were then transferred to the cold tank treating solution for an additional 1 to 120 hours. At the end of their respective

treating periods, the posts were removed from the cold tank, allowed to drain, and reweighed to determine the pounds of solution absorbed per cubic foot of wood (fig. 1). Schedules were varied according to the treatability of each species in order to obtain, if possible, a retention of about 8 pounds per cubic foot. Penetrations were then determined on sample posts, as described above for the cold-soak method.

These periods in the hot bath may cause a loss in moisture content of 5 to 10 percent, or more. Thus the retention values given in tables 6, 7, 8 are presumably somewhat lower than those actually obtained.

The 1944 and 1950 installations were treated with carbolineum. Posts were heated in a barrel of preservative solution for 4 to 8 hours at 190-230°F; then the fire was drawn and posts remained in the cooling preservative for an additional 13 to 18 hours.

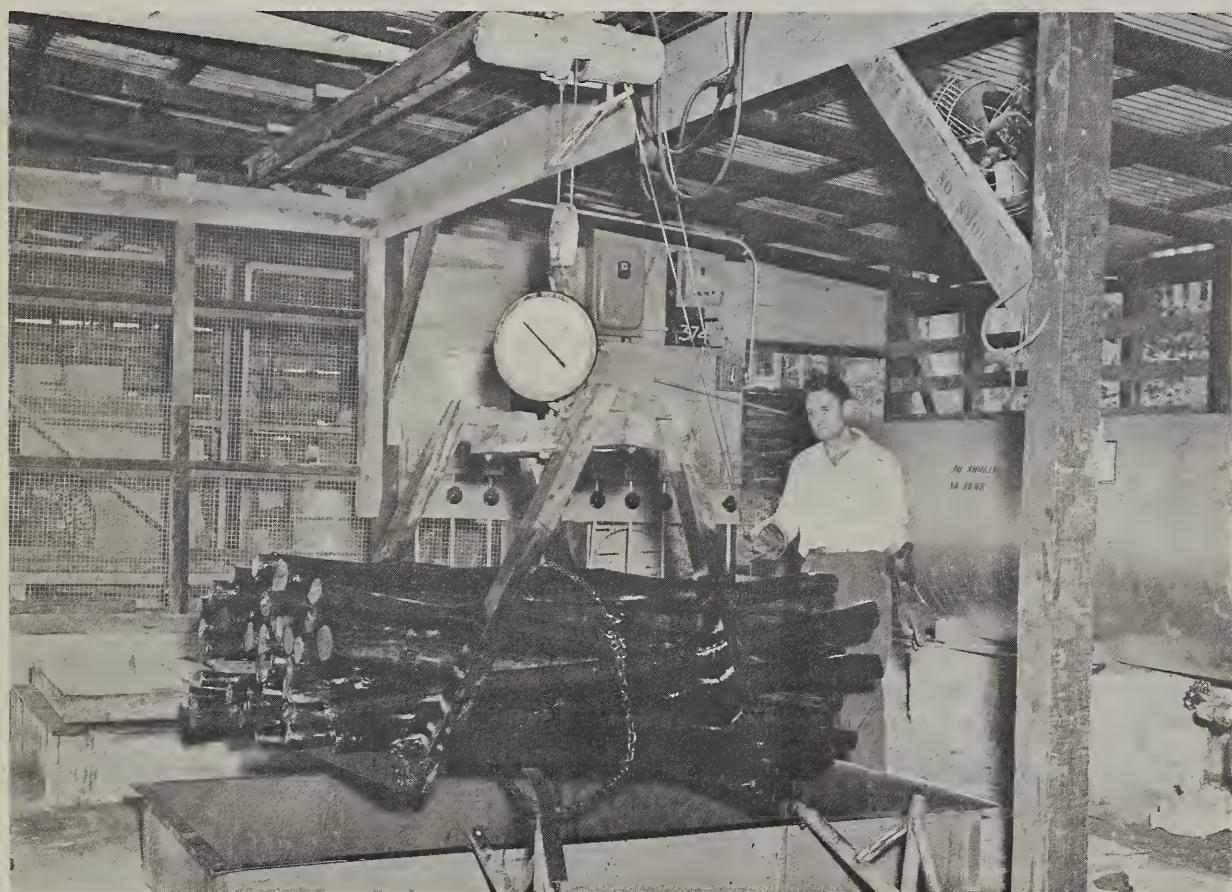


Figure 1. — General view of the experimental hot-and-cold bath treating plant. Posts are being weighed upon removal from the cold tank to determine gross retention.

Borings were taken from posts treated in 1944 for an estimation of side penetration, and a few posts representative of the 1950 treatments were sectioned for these measurements.

A new installation to determine the effect of incising on service life was established in 1967. This trial is represented by 20 posts for each of 18 species. Prior to the preservation treatment, 5 posts were incised full length, 5 were incised from 6 inches above to 18 inches below the groundline, and 10 posts were treated without incising. The incising machine used is shown in figure 2. Details of design and operation were reported by Chudnoff(7). The effect of the incising

pattern used on air drying time, treatability, and bending strength of small diameter posts was also reported (10). A fixed 2 hour - 2 hour hot-and-cold bath schedule was applied to all posts. Treating chemical consisted of a 5 percent solution of pentachlorophenol dissolved in diesel oil.

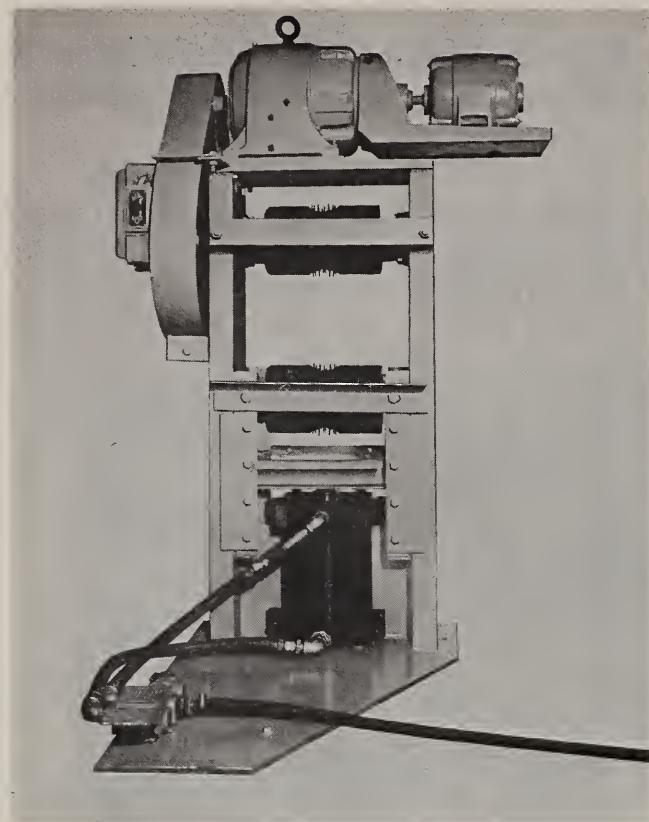


Figure 2. — Post incising machine designed at the Institute of Tropical Forestry showing all-motor type gear reducer, drums, and two-way piston in the "down" position.

Double diffusion

In this method green peeled posts are soaked first in one chemical solution and then in a second solution. The chemicals diffuse into the wood and react with each other to form a toxic compound that is relatively insoluble and resistant to leaching. The posts were treated by two methods: complete immersion in tanks, called the "tank treatment" (T), and end steeping, in which posts are stood upright in a barrel with only the butts in contact with the treating solution, called the "barrel treatment" (B).

For each treating method two chemical combinations were used. In Combination FC the posts were first treated with the sodium fluoride solution for 3 days, then held in the copper sulfate solution for an additional 3 days. Combination CAC consisted of 2 days in the copper sulfate solution followed by 2 days in the mixture of sodium arsenate and sodium chromate. Time schedules for some of the species were modified and are so indicated in table 9.

Upon completion of each double diffusion treatment, the posts were close-piled for several weeks. Not less than 8 weeks after treatment, posts were sampled to determine penetration and chemical absorption. From tank-treated material a cross section disk was removed from the mid-length of each of 5 sample posts representing each species. A 1/4-inch thick section was then cut from each disk and the five sections were ground together to form a composite sample for

determination of chemical retention. Since material from the post ends was not sampled, it is recognized that the results are somewhat lower than the true average; but they do represent retention at the critical groundline.

Five posts from each species treated by the barrel method were sampled for chemical analysis by removing disks 18 inches from the butts and 6 inches from the tops. Composite groundline and composite top samples were then prepared for each species.

Samples were analyzed for the elements known to be present in the preservative solution, i.e. copper and fluorine in those posts treated with Combination FC, and copper, arsenic, and chromium in those posts treated with Combination CAC. The results were calculated to the basis of the chemicals initially used with no effort being made to calculate the amounts of the compounds resulting from reactions within the treated wood.

Radial penetrations of copper sulfate in sample disks removed from the middle portion of posts tank-treated with Combination CAC were determined by spraying the disks with a 1 percent aqueous solution of Chrome Azurol S, a red dye which turns deep blue in the presence of a copper compound. Penetrations were classified into four categories from "complete" to "poor". The results of chemical analyses are given in table 9 along with treating conditions and condition of posts after 12 years of exposure.

INSTALLATION OF POSTS

The various trials are located at four test sites. The largest installation is the Cambalache plot in the northern coastal area, about 8 miles east of Arecibo (fig. 3). Replicates of the more important species were placed in the high-elevation Guavate plot located 23 miles due south of San Juan. The species commonly found in mountain terrain and treated with 10 percent pentachlorophenol are located at Toro Negro, 14 miles northeast of Ponce; other post species growing at low elevations and receiving the same treatment are located on a clay soil in the Cambalache area. Seven species are replicated at the two sites. Three species treated with carbolineum are also replicated at Toro Negro and Cambalache. Several casuarina posts treated with carbolineum have been set out at El Verde, 4 miles south of Río Grande. With few exceptions, untreated posts of each species were installed at each test site.

Data concerning soil, geology, and climatic conditions, believed to be representative of these sites, are given in table 1. Most of the posts at Cambalache are set in a sandy clay loam, and the soils at all the high elevation plots are heavy clays.

Almost all of the posts are set out in randomized blocks and were generally spaced 36 inches within and between rows. The 6-foot posts were installed with their butts 18 inches in the ground. Post stubs were set 12 inches in the soil.

For the 1959-1960 installations there are generally 20 replications per species per treatment at each site except that posts treated by double diffusion using the barrel method have 10 replicates or less. Replications of posts treated with 10 percent pentachlorophenol and carbolineum are variable, ranging from only 2 for some species up to 12 for others.



Figure 3. — The main Cambalache plot showing layout of the test posts.

All posts are identifiable by coded metal tags, and detail maps showing plot locations and post locations within plots were made for reference.

INSPECTION

Posts are inspected annually and tested to determine current serviceability by applying a firm lateral push at the tops. If the post breaks, cause of failure is determined, i.e. fungi or termite attack or both.

The average service life of posts receiving any particular treatment is then determined from mortality curves developed by MacLean (16) and is defined as that period when 60 percent of the posts have failed. Predictions of service life are calculated only for those treatments having 10 percent or more failures. Less failures provide an unreliable basis for use of the curves. Some of these predictions may be modified in future reports, but the data for average service life in tables 2 - 10 for post treatments having 60 percent or more failures are final.

RESULTS TO DATE

Data on treating conditions, chemical retentions, and serviceability are presented in tables 2 - 10. Results as of the April 1972 inspection are as follows:

Untreated control posts (table 2)

Of 1381 untreated posts representing 60 species, set in the ground 12 to 13 years ago, less than 3 percent are still serviceable, 61 percent have been destroyed by decay, 35 percent have failed because of combined decay and termite attack, and less than 1 percent has been destroyed by termite attack alone.

Average service life of all species is about 1.5 years (in 1.5 years we can expect 60 percent failure), but individual species vary from 0.4 to more than 14 years. The longer life of some of the species, i.e. capá blanco, tachuelo, and tea, can be attributed to the presence of a large volume of durable heartwood.

For the 10 species common to both sites, average service life at Cambalache is 1.4 years and at Guavate 1.5 years. A comparison of percentage failures after only one year of service life showed that there have been 42 percent removals at Cambalache and 31 percent at Guavate. Though it appears that conditions for rot in untreated posts are slightly more favorable in the low-land plot, these differences are not statistically significant.

Cold-soak in 5 percent pentachlorophenol in diesel oil (table 3)

The 5-day cold-soak resulted in retentions that varied with species from 0.8 to 10.1 pounds of preservative solution per cubic foot. Side penetration also varied considerably, ranging from 0.1 to 1.6 inches or from 5 to 100 percent of the sapwood radius.

The following species can be classified as having moderately good retention and penetration when treated by this cold-soak method (retention of at least 4.0 pounds per cubic foot and 50 percent or over sapwood penetration):

achiотillo	caimitillo
almácigo	casuarina
cacao motillo	mantequero
caimitillo verde	sabinón
yagrumo hembra	

Of 1280 posts installed at the Cambalache and Guavate plots in 1959, only 6 percent are still serviceable after 13 years, 67 percent have been destroyed by decay, 26 percent by fungi and termite attack, and about 1 percent by termite activity.

All 55 species located at Cambalache have sufficient failures for prediction of service life. This ranges from 3 to 14 years, averaging about 7.1 years. For the 10 species located at both sites, average service life at Cambalache is about 8 years and about 9 years at Guavate. Average retention of the two groups is almost identical, 3.9 and 4.1 pounds of preservative solution per cubic foot respectively.

At the high-hazard Cambalache plot achiotillo, cacao motillo, caimitillo, caimitillo verde, capá blanco, granadillo, hoja menuda, mangle blanco, mangle botón, péndula, and roble have an actual or predicted service life of 10 years or longer. The underlined species were most receptive to this treatment. In contrast almácigo, casuarina, mantequero, sabinón, and yagrumo hembra also had a tolerable absorption and penetration (4 lb per cu. ft and 50 percent respectively) but have an average service life of only 6.2 years.

A 5-day cold-soak in 5 percent pentachlorophenol in diesel oil can extend the average service life of posts from 1.5 years, for nontreated controls, to about 7 years.

All failures to date have been at the groundline. We should expect some vulnerability in the tops of these posts, particularly in those species having very low absorptions, i.e. less than 2 pounds per cubic foot. This has not been the case. Of 492 posts still available for observation at the Cambalache plot in 1969 (including posts that have been removed during previous inspections and were laying on the ground) only 4 posts had moderate to severe decay in the tops. All the others were sound.

Cold-soak in 50-50 creosote-diesel oil (table 4)

The 5- to 7-day cold-soak in the mixture of creosote and diesel oil resulted in species retentions of 1.6 to 5.4 pounds per cubic foot, averaging 4.0 pounds. Side penetration varied from 11 to 60 percent of the sapwood radius.

Of 396 posts installed at both plots (Cambalache and Guavate), 63 or 16 percent are serviceable after 13 years. Seventy percent have been destroyed by decay and 14 percent have failed due to combined decay and insect attack. No posts were lost due to termite attack alone.

Failures at Cambalache have amounted to 85 percent of those installed as compared to 84 percent at Guavate. Species at Cambalache have a predictable service life that ranges from 6 to 15 years, averaging 9 years. At Guavate service life ranges from 8 to 15 years, averaging 10 years.

For the same species given a cold-soak treatment with 5 percent pentachlorophenol and 50-50 creosote mix located at Cambalache and Guavate, the preservative absorptions and penetrations are about identical. However, the creosote mix at both locations, appears to extend average service life by about one year beyond that of the "penta" treatments.

Cold-soak in 10 percent pentachlorophenol in diesel oil (table 5)

These posts were treated butt down in the preservative solution. Some of the species had light to severe wood borer attack prior to the treatment. Test posts were 4 feet long with a top diameter of about 3 inches.

At Cambalache retentions of the 21 species tested ranged from 2.1 to 15.1 pounds per cubic foot, averaging 5.9. Of those 16 species set at Toro Negro, retentions varied from 5.0 to 9.7 pounds per cubic foot and averaged 6.8 pounds per cubic foot. No penetration data are available for these stubs.

Of 122 posts installed at Cambalache, only 3 or 2 percent are serviceable after 20 years of ground contact; 116 or 96 percent have been destroyed by decay fungi; and only 3 posts have been lost due to combined decay and termite attack. Of 89 posts installed at Toro Negro, 53 or 60 percent are serviceable, 34 or 38 percent have been destroyed by decay fungi. There are 2 failures attributable partially to termite attack.

For the same seven species located at both plots, there have been 94 percent failure at Cambalache and 47 percent loss at Toro Negro. Average preservative retentions are 5.9 and 6.7 per cubic foot respectively.

For all the species at Cambalache, service life estimates range from 5 to 17 years, averaging about 12 years. Twelve of the 16 species installed at Toro Negro have sufficient failures for predicting average life and this ranges from 13 to 31 years, averaging 21 years.

There are 14 replicated species at the Cambalache plots, one group treated by cold soaking with 5 percent pentachlorophenol and the other with a 10 percent concentration. Those treated with the 5 percent concentration have an average service life of 6.9 years while those treated with the 10 percent concentration have an average service life of 12.1 years. It should be noted that average retention of preserving oils are respectively 3.5 and 6.6 pounds per cubic foot or more appropriately 0.18 and 0.66 pound of dry "penta" per cubic foot.

Many of the posts treated with 10 percent pentachlorophenol had mild to severe insect attack before treatment and this could account for the higher solution absorption. Individual posts of those species that had varying degrees of insect damage prior to treatment generally show higher preservative absorptions in the more severely attacked posts.

A large part of the higher retentions in the 10 percent treatment, however, can be attributed to the method of cold soaking. If we compare the retention of those six species treated with 10 percent pentachlorophenol, that were free of insect attack prior to treatment, with the same species preserved with 5 percent pentachlorophenol, we find that the average absorptions are respectively 6.2 and 3.8 pounds per cubic foot. The posts treated with the 10 percent solution were submerged butt down in a relatively deep tank and greater hydrostatic pressure could force a larger quantity of preservative into the wood than would be absorbed if submerged in a horizontal position. The use of this technique to increase absorption has been described by Walters (17), Walters and Meek (18), and Blew (5).

Except for uvilla and tortugo amarillo, the serviceability of all the species is most satisfactory. This vertical cold-soak technique appears to be adaptable to a wide choice of species. It must be realized, however, that the pentachlorophenol consumption is almost four times greater than for the more conventional horizontal cold-soak treatment described above.

Hot-and-cold bath, 5 percent pentachlorophenol in diesel oil (table 6)

Retention by species ranged from 2.0 to 25.0 pounds per cubic foot, averaging 9.2 pounds. Side penetration was generally good, varying from 35 to 100 percent of the sapwood radius.

After 13 years of service, 246 out of 773 or 32 percent of the posts installed at Cambalache and Guavate have been destroyed. There were no losses attributable to termite attack alone. Six of the 29 species have no failures at either plot and no predictable service life. For the remaining species average service life ranges from a low of 7.0 years for bambú to an estimated 20 years for camasey blanco, guaba, and guamá, averaging about 15 years for both sites combined.

Time in the hot-and-cold baths was varied considerably according to the treatability of each species and in some cases absorptions are excessive. Most of the longer schedules cannot be recommended for a commercial operation and more feasible cycles are now being developed. (Note table 10).

Hot-and-cold bath, 50-50 creosote-diesel oil solution (table 7)

As for the same method using pentachlorophenol, widely different schedules were adopted. Species retentions varied from 5.4 to 13.1 pounds per cubic foot, averaging 8.5 pounds. Side penetration ranged from 59 to 100 percent of the sapwood radius.

Only 55 creosoted posts of 400 or 14 percent of those installed at Cambalache and Guavate have failed after 13 years of service. This compares with the 58 failures shown by the 10 matched species treated with 5 percent pentachlorophenol. Both preservative formulations, then, are having about the same effectiveness.

For those 7 out of 10 species having a predictable service life at either plot, this ranges from 15 to 20 years and averages about 18.

Hot-and-cold bath, carbolineum (table 8)

Posts treated with carbolineum represent the oldest test installation under review in this report. Posts installed in 1950 were 6 feet long and had top diameters that ranged from 3 to 5 inches; those set out in 1944 were 3- to 4-foot long stubs with top diameters of 5 to 6 inches.

Retention for the three species treated in 1950 (Cambalache and Toro Negro) ranged from 5 to 9 pounds per cubic foot with an irregular side penetration. The casuarina posts installed in 1944 (El Verde) have excessively high retentions, averaging 20 pounds per cubic foot, with a side penetration of about 1 inch or 30 percent of the sapwood radius.

There are no failures in the 1950 installations. Of six casuarina posts installed in 1944 there has been one failure, which indicates an average predicted service life of 38 years.

Double-diffusion (table 9)

A. Tank treatments (T). —Dry salt retentions of Combination FC (sodium fluoride followed by copper sulfate) varied from 0.07 pound per cubic foot for mangle blanco to 0.60 pound per cubic foot for the eucalypt. Average retention for all species is 0.34 pound per cubic foot. Total salt concentration used in Combination CAC (copper sulfate followed by a mixture of sodium chromate and sodium arsenate) is about double that of Combination FC and retentions ranges from 0.28 pound per cubic foot for caimitillo to 1.44 pounds per cubic foot for almendra, averaging 0.76 pound.

Of 666 posts treated by Combination FC, there have been, after 12 years of exposure, 74 percent failures. All of the 29 species located at Cambalache and Guavate have sufficient failures to predict an average service life of 10.0 years, ranging from 2 years for bambú to 18 years for roble. For the 6 species replicated at both sites, average life at Cambalache is 9 years and 11 years at Guavate.

Fifty-three percent of the 692 posts treated with the salt Combination CAC have failed. Twenty-seven of the 29 species at Cambalache and Guavate have a predictable service life of 10.6 years, varying from 4 to 12 years. Five of the 6 species replicated at both sites have an average service life of 11 years at Cambalache and 13 years at Guavate (roble has no failures at either site).

Penetration data are available only for posts treated with the Combination CAC salts and about 62 percent of the failures were in those species having fair or poor penetration.

For the same 6 species located at Cambalache and Guavate, treatment with the more concentrated Combination CAC increases average service life at both plots by about 2 years.

B. Barrel or end diffusion treatments (B). — Groundline retentions of posts treated with Combination FC varied with species from 0.13 to 0.99 pound per cubic foot, averaging 0.66 pound. Posts treated with Combination CAC have dry salt retentions varying from 0.69 to 4.33 pounds per cubic foot, averaging 1.44 pounds.

Movement of the chemicals to the top of the posts by end diffusion was negligible. In almost all cases, the absorption in the tops is considerably less than 0.1 pound per cubic foot. Though not shown in table 9, a large number of the posts treated by the barrel method were classified non-serviceable due to severe decay and termite attack in the tops and not because of failure at the groundline.

Of a total of 252 posts treated with Combination FC, 98 percent have failed after 12 years of service; compared to 85 percent failures in those 273 posts treated with Combination CAC.

All of the species treated with Combination FC have sufficient failures for predicting average service life. This ranges from about 2 to 10 years, averaging 6.4 years. Twenty-eight of the twenty-nine species treated with Combination CAC have a predictable service life which ranges from 2 to 14 years, averaging 8.2 years.

Optimum retentions of these water-borne preservatives, as applied to tropical hardwoods, are still not clearly defined. Minimum requirements should be at least those specified for the various salt combinations used to treat coniferous post species in a more temperate climate, i.e. 0.5 to 1.0 pound of dry salt per cubic foot (1). The tank treatment using the copper arsenate chromate combination appears to be most suitable as only 4 species (caimitillo, cassia de Siam, guamá, and maría) out of the 29 under evaluation have less than minimal retention. Species that should show particular promise are those having a good to excellent penetration, as well, and they are:

achiотillo	laurel geo
almácigo	teca
almendra	tulipán africano
camasey blanco	verde seco
eucalipto (robusta)	yagrumo hembra
guava	yagrumo macho

After 12 years of service these 12 species installed at Cambalache have about 56 percent removals. The remaining 17 species that had low chemical retention or poor to fair penetration, have about 54 percent removals. This may suggest that the salts in the high retention species were not well fixed against leaching.

Incising plus hot-and-cold bath, 5 percent pentachlorophenol in diesel oil (table 10)

Eighteen species are in this test group. Without incising 11 of these had preservative absorptions less than 6.0 lb per cu. ft and 14 had penetrations less than 0.6 in. Four of those that were incised full length have absorptions less than 6.0 lb per cu. ft All have penetrations of 0.6 in. or more.

After 5 years of service, there is only one failure out of a total of 348 posts under test. This excellent record to date indicates an average service life of over 20 years is to be anticipated.

CONCLUSIONS

1. Whether established in a coastal or mountain area, average service life of untreated posts is only 1.5 years, individual species range from 0.4 to 3.6 years. Exceptions are capá blanco, tachuelo, and tea with an excellent serviceability that can be attributed to the presence of a large volume of durable heartwood.
2. Although termite attack may be locally severe, decay fungi cause most of the failures.
3. During the first few years of exposure, preservative treated posts, established at the several high elevation plots, have much fewer failures than matched material placed in the low-land Cambalache plot. However, after a test time of 12-13 years these differences are reduced and posts set out in mountain areas may last only 1-2 years longer than those on a coastal site.
4. All 55 species located at Cambalache and treated by cold soaking for 5 days in 5 percent pentachlorophenol dissolved in diesel oil have sufficient failures for predicting a service life of 3 to 14 years, averaging 7 years. Achiotillo, cacao motillo, caimitillo, and caimitillo verde are the few species most receptive to this treatment and have an average service life of 10 years or longer.
5. For the same 10 species given a 5-day cold-soak treatment with 5 percent pentachlorophenol and a similar soak with 50-50 creosote-diesel oil, the solution absorptions and penetrations are almost identical. However, the creosote mix appears to be somewhat more effective, extending service life by about one year.
6. Posts treated with a 10 percent concentration of pentachlorophenol in diesel oil by cold soaking in a vertical position butt down for 5 days have, with the exception of poor performers uvilla and tortugo amarillo, an average service life of 12 years at Cambalache. Other species set out at Toro Negro have an estimated average service life of 21 years. A comparison of matched species shows that vertical cold soaking, using a 10 percent preservative concentration, increases chemical absorption about fourfold over that obtainable with posts treated in a horizontal position using a 5 percent solution.

7. After 13 years of ground contact, posts treated by the hot-and-cold bath using pentachlorophenol or the creosote mix have 301 failures out of 1,172 posts of all species combined. A substantial number of species have too few failures for estimating average service life. Where predictions are possible, this averages 16-18 years for the pentachlorophenol treatment and 17-18 years for the matched creosote treatment.

8. The few species treated by the hot-and-cold bath method using carbolineum have almost no failures after more than 20 years of service. At the one site where average life is predictable, this is about 38 years.

9. The most promising double diffusion treatment is the tank method using a 2-day soak in 10 percent copper sulfate followed by a 2-day soak in a mixture of 6.5 percent sodium arsenate and 6.5 percent sodium chromate. Average service life for all species combined is about 11 years. This is intermediate in effectiveness between cold soaking and the hot-and-cold bath method using either pentachlorophenol or creosote.

10. Incised and matched non-incised posts treated by a uniform 2 hour -2 hour hot-and-cold bath schedule using 5 percent pentachlorophenol in diesel oil have been in service 5 years. There is only one failure out of 348 posts installed that is attributable to decay or insect attack. An average service life well over 20 years is anticipated.

Table 1.--DESCRIPTION OF TEST PLOT SITES.

Item	Location			
	Cambalache	Guavate	Toro Negro	El Verde
Elevation (ft)	100	2100	2900	1120
Soil	clay to sandy clay loam pH 5.9	clay pH 5.3	clay pH 5.1	clay pH 5.4
Geology	deposited from coastal materials	residual from volcanic rock	residual from volcanic rock	residual from volcanic rock
Temperature (°F)				
mean coldest month	74.0	69.3	65.8	69.3
mean hottest month	80.4	75.9	72.1	76.1
mean annual	77.6	73.1	69.3	73.1
Rainfall (in.)				
Sept.-Nov.	16.0	17.3	37.6	29.4
Dec.-Feb.	16.4	11.2	13.4	13.5
Mar.-May	11.6	14.4	24.6	24.1
June-Aug.	12.5	39.7	23.8	32.0
mean annual	56.5	82.6	99.4	99.0

Table 2.--CONDITION OF UNTREATED CONTROL POSTS INSTALLED IN THE CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS,
PUERTO RICO AFTER 13 YEARS OF SERVICE. POSTS INSTALLED IN APRIL 1959.

Species	Location	Posts in test	Condition of posts, April 1972				Total removed	Average life		
			Serv- iceable	Removed because of						
				Decay	Decay & termites	Termites				
		No.	No.	No.	No.	No.	No.	Pct.		
Achiotillo	CA	19	--	9	10	--	19	100		
Aguacatillo	CA	20	--	18	2	--	20	100		
Almácigo	CA	20	--	18	2	--	20	100		
Almendra	CA	20	--	13	7	--	20	100		
Ausubo	CA	20	--	8	11	1	20	100		
Bambú	CA	20	--	17	3	--	20	100		
"	GU	17	--	16	1	--	17	100		
Cacao motillo	CA	20	--	6	14	--	20	100		
Caimilito verde	CA	20	--	15	5	--	20	100		
Camasey jusillo	CA	19	--	12	7	--	19	100		
Camasey blanco	CA	20	--	17	3	--	20	100		
" "	GU	20	--	20	--	--	20	100		
Caoba dominicana ^{2/}	CA	20	1	10	9	--	19	95		
Capá blanco	CA	17	3	5	9	--	14	82		
Caracolillo	CA	19	--	12	7	--	19	100		
Cassia de Siam	CA	20	--	14	6	--	20	100		
Casuarina	CA	20	--	6	14	--	20	100		
" "	GU	20	--	19	1	--	20	100		
Cieneguillo	CA	20	--	13	7	--	20	100		
Cucubano	CA	20	--	10	10	--	20	100		
Espino rubial	CA	19	--	9	10	--	19	100		
Eucalipto (robusta)	CA	20	--	6	13	--	20	100		
Granadillo	CA	19	--	9	10	--	19	100		
Guaba	CA	20	--	11	9	--	20	100		
" "	GU	18	--	18	--	--	18	100		
Guamá	CA	19	--	11	8	--	19	100		
" "	GU	20	--	19	1	--	20	100		
Guaraguao	CA	20	--	9	11	--	20	100		
Hoja menuda	CA	20	--	10	10	--	20	100		
" "	GU	20	--	18	2	--	20	100		
Hueso blanco	CA	20	--	12	8	--	20	100		
Jaguey	CA	20	--	13	7	--	20	100		
Laurel avispillo	CA	20	--	10	10	--	20	100		
Laurel geo	CA	18	--	4	14	--	18	100		
" "	GU	19	--	19	--	--	19	100		
Mangle blanco	CA	20	--	3	13	4	20	100		
" "	GU	20	--	18	2	--	20	100		
Mangle colorado	CA	20	--	12	8	--	20	100		
Mangle botón	CA	20	3	6	11	--	17	85		
Mantequero	CA	19	--	3	16	--	19	100		
Manzanillo	CA	19	--	2	16	1	19	100		
María	CA	20	--	7	13	--	20	100		
Maricao	CA	19	--	15	4	--	19	100		
Masa	CA	20	--	6	13	1	20	100		
Mesa	CA	20	--	11	9	--	20	100		
Moca	CA	20	--	13	7	--	20	100		
Moral	CA	20	--	11	9	--	20	100		
Muñeco	CA	17	--	8	9	--	17	100		
Negra lora	CA	20	--	10	10	--	20	100		
Palo de gallina	CA	20	--	15	5	--	20	100		
Palo de matos	CA	20	--	7	13	--	20	100		
Péndula	CA	14	--	7	7	--	14	100		
Pomarrosa	CA	18	--	3	14	1	18	100		
" "	GU	20	--	19	1	--	20	100		
Rabo de ratón	CA	20	--	12	8	--	20	100		
" " "	GU	20	--	20	--	--	20	100		
Retama ^{2/}	CA	20	--	17	2	1	20	100		
Roble	CA	20	--	15	5	--	20	100		
" "	GU	20	--	18	2	--	20	100		
Sabinón	CA	20	--	6	14	--	20	100		
Tabonuco	CA	18	--	11	7	--	18	100		
Tachuelo	CA	20	8	10	2	--	12	60		
Tea	CA	20	20	--	--	--	--	--		
Teca	CA	20	--	10	10	--	20	100		
Tulipán africano	CA	20	--	17	3	--	20	100		
Ucar	CA	17	--	16	1	--	17	100		
Uvilla	CA	20	--	11	8	1	20	100		
Verde seco ^{2/}	CA	21	--	19	2	--	21	100		
Yagrumo hembra	CA	17	--	12	5	--	17	100		
Yagrumo macho	CA	20	--	10	10	--	20	100		
Zarcilla	CA	19	--	19	--	--	19	100		

^{1/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed.
When percentage of posts removed is less than 10 percent, no estimate on average life is given.

^{2/} Posts in service 12 years at time of last inspection.

Table 3.--CONDITION OF ROUND POSTS TREATED BY COLD SOAKING FOR 5 DAYS IN 5% PENTACHLOROPHENOL DISSOLVED IN DIESEL OIL AFTER ABOUT 13 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO. POSTS INSTALLED IN APRIL 1959.

Species															
	Location	in	Posts	Retention of preservative	test	Min.	Max.	Avg.	Average side penetration of sapwood radius	Servicable	Removed because of Decay	Decay & Termites	Total removed	Average life	
	No.	Lb. per cu.ft.	Lb. per cu.ft.	Lb. per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	No.	Pct.	Yr.	
Achiotillo	CA	19	6.2	13.1	8.4	1.63	100	4	13	2	--	15	79	9.9	
Aguacatillo	CA	20	.6	3.2	1.6	.10	7	--	18	2	--	20	100	4.4	
Almácigo	CA	18	4.3	8.9	6.1	1.07	85	--	18	--	--	18	100	4.2	
Almendra	CA	18	1.6	3.2	2.2	.33	34	--	15	3	--	18	100	6.6	
Ausubo	CA	20	1.9	3.9	2.6	.52	36	1	9	9	1	19	95	7.8	
Bambú	CA	20	--	--	--	--	--	--	20	--	--	20	100	6.3	
Cacao motillo	CA	20	3.8	8.1	5.3	1.35	92	3	3	14	--	17	85	10.4	
Caimitillo	CA	20	5.1	9.3	7.4	1.13	79	9	6	5	--	11	55	13.7	
Caimitillo verde	CA	20	--	--	5.7	.64	46	6	14	--	--	14	70	12.4	
Camasey blanco	CA	20	1.2	3.6	2.3	.10	8	1	15	4	--	19	95	8.5	
" "	GU	20	1.6	3.0	2.4	.10	8	--	19	1	--	20	100	8.5	
Camasey jusillo	CA	20	1.4	3.2	2.1	.10	8	--	11	9	--	20	100	9.4	
Capá blanco	CA	20	1.7	6.4	2.6	.31	26	4	10	6	--	16	80	10.0	
Caracolillo	CA	20	1.3	2.9	2.1	.42	28	--	14	5	1	20	100	7.3	
Cassia de Siam	CA	20	3.1	6.6	4.8	.62	42	2	15	3	--	18	90	7.8	
Casuarina	CA	20	3.9	8.4	5.6	.93	72	3	10	7	--	17	85	9.2	
" "	GU	20	3.7	7.5	5.4	.93	72	8	11	1	--	12	60	13.0	
Cieneguillo	CA	20	.5	2.0	.8	.15	11	1	5	13	1	19	95	7.0	
Cucubano	CA	20	1.8	3.6	2.5	.17	13	--	17	3	--	20	100	7.5	
Espino rubial	CA	19	2.1	3.1	2.6	.19	17	--	15	4	--	19	100	2.7	
Eucalipto (robusta)	CA	20	.9	3.9	2.1	.17	22	--	14	6	--	20	100	6.8	
Granadillo	CA	20	2.1	5.9	3.1	.41	46	2	16	2	--	18	90	10.4	
Guaba	CA	20	2.5	5.5	3.9	.25	20	--	17	3	--	20	100	7.0	
" "	GU	20	2.7	5.4	4.1	.25	20	1	19	--	--	19	95	7.5	
Guamá	CA	20	2.0	6.9	3.4	.34	31	--	20	--	--	20	100	6.5	
" "	GU	20	1.8	6.7	3.6	.34	31	--	18	2	--	20	100	9.4	
Guaraguao	CA	20	2.3	4.8	3.4	.97	79	--	17	3	--	20	100	7.8	
Hoja menuda	CA	20	1.4	3.9	2.6	.16	13	2	9	9	--	18	90	9.6	
" "	GU	20	1.8	3.5	2.7	.16	13	1	13	6	--	19	95	9.2	
Hueso blanco	CA	20	1.1	2.5	1.9	.59	45	1	6	13	--	19	95	7.5	
Jagüey	CA	20	1.9	5.6	2.6	.41	28	--	15	5	--	20	100	3.7	
Laurel avispollo	CA	19	1.5	3.0	2.2	.53	41	--	12	6	1	19	100	3.6	
Laurel geo	CA	21	3.0	7.4	5.0	.34	27	1	16	4	--	20	95	7.1	
" "	GU	20	3.7	7.6	5.3	.34	27	--	20	--	--	20	100	7.0	
Mangle blanco	CA	20	1.9	6.8	3.4	.59	52	1	7	12	--	19	95	10.0	
" "	GU	20	2.3	5.3	3.4	.59	52	2	8	10	--	18	90	10.4	
Mangle botón	CA	20	1.7	4.0	2.5	.48	44	5	10	5	--	15	75	9.7	
Mangle colorado	CA	19	2.2	3.5	3.0	.73	60	--	8	10	1	19	100	4.5	
Mantequero	CA	19	4.1	9.7	6.3	.70	50	--	10	9	--	19	100	4.2	
Manzanillo	CA	18	5.1	8.1	6.2	.52	33	--	13	5	--	18	100	6.7	
María	CA	20	2.2	6.4	4.1	.34	24	1	12	7	--	19	95	7.8	
Maricáo	CA	20	1.9	4.2	2.8	.32	22	--	11	9	--	20	100	7.3	
Masa	CA	20	1.0	2.6	1.8	.20	16	--	3	12	5	20	100	3.4	
Moca	CA	20	2.8	4.8	3.8	.89	69	--	17	3	--	20	100	7.5	
Moral	CA	17	2.5	6.0	3.5	.29	28	--	11	5	1	20	100	4.3	
Muñeco	CA	20	3.3	7.0	4.9	.52	40	--	16	4	--	20	100	7.0	
Negra lora	CA	19	1.4	4.1	2.6	.06	5	--	13	6	--	19	100	7.1	
Palo de gallina	CA	20	2.7	5.4	4.0	.14	10	--	16	3	1	20	100	6.0	
Palo de matos	CA	20	2.2	5.4	3.1	.28	23	2	12	6	--	18	90	7.5	
Péndula	CA	20	1.1	2.9	1.9	.20	14	3	15	2	--	17	85	9.7	
Pomarrosa	CA	20	3.2	6.7	4.9	.31	22	--	8	12	--	20	100	6.0	
" "	GU	20	2.7	7.1	4.9	.31	22	--	14	6	--	20	100	8.0	
Rabo de ratón	CA	20	2.8	6.2	4.6	.39	32	--	13	7	--	20	100	7.0	
" " "	GU	20	3.2	7.0	4.4	.39	32	--	19	1	--	20	100	6.5	
Roble	CA	20	3.3	5.7	4.3	.53	37	11	8	1	--	9	45	14.5	
" "	GU	20	3.7	5.9	4.7	.53	37	5	14	1	--	15	75	12.5	
Sabinón	CA	20	6.7	13.6	10.1	.91	69	2	15	3	--	18	90	9.4	
Tabonuco	CA	18	1.4	3.5	2.0	.12	8	--	7	9	2	18	100	3.8	
Teca	CA	19	1.0	2.6	1.6	.50	51	--	13	5	1	19	100	5.9	
Tulipán africano	CA	20	3.1	6.2	4.4	.19	17	1	17	2	--	19	95	6.0	
Ucar	CA	20	1.0	2.2	1.5	.10	9	--	10	10	--	20	100	7.1	
Uvilla	CA	20	2.1	5.4	3.5	.40	29	--	19	1	--	20	100	4.7	
Yagrumo hembra	CA	19	2.1	6.1	4.1	.65	50	--	16	3	--	19	100	4.1	
Yagrumo macho	CA	18	2.8	5.5	3.6	.81	56	--	15	3	--	18	100	3.4	
Zarcilla	CA	20	.9	2.5	1.5	--	--	--	14	5	1	20	100	3.4	

^{1/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 4.—CONDITION OF ROUND POSTS TREATED BY COLD SOAKING IN 50% CREOSOTE - 50% DIESEL OIL AFTER ABOUT
13 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO. TREATED POSTS
INSTALLED IN APRIL 1959.

Species	Location	Posts in test	Treat- ing time	Retention of preservative	Average side penetration of sapwood radius	Condition of posts, April 1972		Total removed	Average life/ life	
						Serv- iceable	Removed because of decay & termites			
No.	Hrs.	Lb. per cu. ft.	Lb. per cu. ft.	In.	Pct.	No.	No.	No.	Pct.	Yr.
Camasey blanco " "	CA GU	20 19	120 120	.6 .8	2.7 2.6	1.6 1.8	.14 .14	11 11	1 1	18 18
Casuarina "	CA GU	19 20	120 120	2.4 3.6	8.8 6.9	5.3 5.1	.81 .81	55 55	4 5	13 14
Guaba "	CA GU	20 19	168 168	2.4 3.4	6.3 5.6	4.2 4.2	.12 .12	13 13	3 3	17 19
Guamá "	CA GU	20 20	168 168	2.8 2.4	5.8 5.7	4.2 3.6	.71 .71	53 53	4 2	18 18
Hoja menuda "	CA GU	20 20	120 120	1.7 1.9	3.7 4.0	2.8 2.8	.14 .14	11 11	-- --	-- --
Laurel geo "	CA GU	20 20	120 120	3.9 3.6	7.1 7.8	5.1 5.3	.22 .22	16 16	4 1	15 17
Mangle blanco "	CA GU	19 20	120 120	1.8 1.9	5.3 6.6	3.2 3.0	.39 .39	60 60	2 8	6 9
Pomarrosa "	CA GU	20 21	120 120	3.1 1.8	5.6 6.6	4.6 4.6	.31 .31	22 22	-- 1	11 19
Rabo de ratón "	CA GU	20 19	120 120	4.0 4.1	6.1 6.9	4.9 5.4	.63 .63	50 50	1 1	18 17
Roble "	CA GU	20 20	120 120	3.0 3.0	6.2 6.1	4.5 4.6	.40 .40	29 29	7 7	-- --

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 5.--CONDITION OF ROUND POSTS TREATED BY COLD SOAKING FOR 5 DAYS IN 10% PENTACHLOROPHENOL DISSOLVED IN DIESEL OIL AFTER ABOUT 20 YEARS OF SERVICE. CAMBALACHE AND TORO NEGRO TEST PLOTS, PUERTO RICO. POSTS INSTALLED IN APRIL 1952.

Species	No.	Lb.per cu.ft.	Lb.per cu.ft.	CAMBALACHE TEST PLOT				TORO NEGRO TEST PLOT				
				Posts in test	Retention of preservative	Insect ^{1/} attack	Servable	Condition of posts, April 1972	Removed because of Decay & Termites	Total removed	Average life	
				Min.	Max.	Av.	prior to treatment	iceable	Termites	No.	No.	Pct.
Abeyuelo	3	2.7	4.4	3.5	0	--	--	3	--	3	100	13.3
Acacia amarilla	9	4.6	12.0	7.3	L-H	1	8	--	8	8	89	14.2
Almácigo	8	12.9	18.7	15.1	0	--	8	--	--	8	100	8.9
Caimitillo de perro	10	2.1	6.2	4.6	0	--	10	--	--	10	100	11.5
Camasey de felpa	3	1.8	2.6	2.1	0	--	3	--	--	3	100	9.5
Cassia de Siam	10	3.3	7.2	4.3	O-H	--	10	--	--	10	100	14.0
Guácumo	10	5.2	11.1	7.9	0	--	10	--	--	10	100	10.9
Guamá	4	4.2	9.1	6.2	O-H	--	4	--	--	4	100	10.5
Jaguey	4	3.8	4.2	4.0	O-L	--	3	1	--	4	100	12.8
Mangle blanco	7	9.0	13.7	12.2	M-H	--	7	--	--	7	100	11.7
Mangle botón	9	2.6	4.2	3.4	0	--	8	1	--	9	100	11.0
Moca	5	3.0	8.0	6.2	O-H	--	5	--	--	5	100	11.5
Moral	3	5.3	8.3	6.9	0	--	3	--	--	3	100	11.0
Péndula	3	1.4	3.3	2.4	0	--	3	--	--	3	100	11.0
Rabo de ratón	5	3.3	6.0	4.4	0	--	1	4	--	4	80	14.0
Roble	5	4.0	6.0	5.0	0	--	1	4	--	4	80	15.0
Tabloncillo	3	3.3	6.2	4.6	0	--	3	--	--	3	100	9.5
Tortugo amarillo	3	2.9	4.2	3.8	0	--	3	--	--	3	100	5.4
Uvilla	3	2.0	3.6	2.9	O-H	--	3	--	--	3	100	6.0
Vagrumo macho	5	7.0	10.2	8.7	O-H	--	4	1	--	5	100	15.0
Zarcilla	10	7.0	12.7	8.9	H	--	10	--	--	10	100	17.0
Cacao motillo	3	7.0	8.6	7.9	L-M	2	--	1	--	1	33	24.0
Caimitillo (mesa)	10	3.7	9.3	7.2	0	9	1	--	--	1	10	30.8
Caimitillo verde	3	6.9	7.7	7.3	0	3	--	--	--	--	--	--
Eucalipto (patentinervis)	3	6.8	7.7	7.2	0	3	--	--	--	--	--	--
Eucalipto (robusta)	3	5.4	8.2	6.5	0	2	1	--	--	1	33	24.0
Guacimilla	9	5.3	8.7	6.7	O-L	1	8	--	--	8	89	13.4
Guaba	10	3.8	11.3	6.0	O-H	7	3	--	--	3	30	25.0
Guamá	5	3.4	10.8	7.6	L-H	3	2	--	--	2	40	23.0
Jaguey	4	4.2	6.7	5.6	M-H	1	3	--	--	3	75	15.6
María	4	6.8	7.2	7.0	0	4	--	--	--	--	--	--
Moca	5	4.1	7.0	5.7	O-H	--	5	--	--	5	100	15.0
Moral	5	6.0	9.5	8.0	O-M	2	3	--	--	3	60	17.0
Palo de matos	10	3.9	8.2	5.4	O-M	4	5	1	--	6	60	19.0
Rabo de ratón	6	3.5	7.7	5.0	O-H	4	2	--	--	2	33	24.0
Roble	5	4.5	6.8	5.7	O-H	5	--	--	--	--	--	--
Vagrumo macho	4	7.3	11.1	9.7	O-H	3	1	--	--	1	25	26.0

1/ 0 = none; L = light; M = medium; H = heavy.

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 6.--CONDITION OF ROUND POSTS TREATED BY HOT-AND-COLD BATH USING 5% PENTACHLOROPHENOL DISSOLVED IN DIESEL OIL AFTER ABOUT 13 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO.
TREATED POSTS INSTALLED IN APRIL 1959.

Species																	
	Posts	Treat-	Retention of preservative		Average side penetration of sapwood radius	Condition of posts, April 1972	Serv-	Removed because of iceable Decay	Decay & Termites	Total removed	Average life	No.	Pct.	Yr.			
	Location	in test	time ^{1/}	Min. : Max. : Av.								No.	No.	No.	No.	No.	
Achiotillo	CA	20	1-1	9.5	18.9	15.6	1.50	100	12	8	--	--	8	40	14.9		
Almendra	CA	19	1-3	7.4	12.8	9.5	1.40	100	4	12	3	--	15	79	9.3		
Bambú	CA	20	2-1	--	--	--	--	--	20	--	--	--	20	100	7.0		
Cacao motillo	CA	20	4-3	6.9	12.6	9.0	1.27	100	14	4	2	--	6	30	16.3		
Caimitillo	CA	20	4-3	5.7	11.9	8.5	.96	82	13	4	3	--	7	35	15.3		
Camasey blanco	CA	20	3-120	4.0	11.7	7.4	1.01	84	15	4	1	--	5	25	16.8		
" "	GU	20	3-120	3.4	12.1	7.2	1.01	84	18	2	--	--	2	10	20.0		
Camasey jusillo	CA	19	1-48	6.0	9.0	6.8	--	--	19	--	--	--	--	--	--		
Cassia de Siam	CA	20	4-3	7.2	12.5	9.1	.53	42	15	4	1	--	5	25	15.6		
Casuarina	CA	20	15-120	6.1	10.6	7.5	1.54	100	20	--	--	--	--	--	--		
" "	GU	20	15-120	6.3	10.5	7.8	1.54	100	20	--	--	--	--	--	--		
Eucalipto (robusta)	CA	19	2-4	6.2	14.6	9.1	.84	100	9	9	1	--	10	53	13.7		
Guaba	CA	20	3-5	6.1	14.3	8.9	.76	64	19	1	--	--	1	5	--		
" "	GU	20	3-5	6.7	14.0	9.8	.76	64	18	2	--	--	2	10	20.0		
Guamá	CA	20	3-5	4.2	15.0	7.4	1.25	87	18	2	--	--	2	10	20.0		
" "	GU	20	3-5	4.5	13.1	8.4	1.25	87	16	4	--	--	4	20	17.6		
Hoja menuda	CA	20	4-120	5.2	9.6	7.4	1.44	100	17	3	--	--	3	15	18.6		
" "	GU	19	4-120	4.0	9.4	6.8	1.44	100	18	1	--	--	1	5	--		
Laurel geo	CA	20	15-24	18.9	31.1	25.0	1.60	100	16	4	--	--	4	20	17.6		
" "	GU	20	15-24	12.9	30.0	23.5	1.60	100	16	4	--	--	4	20	17.3		
Mangle blanco	CA	20	5-120	2.9	9.0	5.2	.92	100	6	7	7	--	14	70	10.0		
" "	GU	20	5-120	2.8	12.4	6.3	.92	100	16	4	--	--	4	20	17.3		
Mangle botón	CA	20	2-10	4.2	6.9	5.2	1.30	100	20	--	--	--	--	--	--		
María	CA	20	2-10	14.0	19.1	16.8	1.33	100	20	--	--	--	--	--	--		
Moca	CA	19	2-10	3.7	12.7	7.0	1.15	82	14	4	1	--	5	26	16.7		
Moral	CA	21	1-4	6.2	11.7	8.0	--	--	10	11	--	--	11	52	13.7		
Péndula	CA	20	2-10	2.1	5.8	3.9	.57	41	19	1	--	--	1	5	--		
Pomarrosa	CA	20	5-29	8.5	13.8	10.7	1.37	100	15	4	1	--	5	25	16.7		
" "	GU	20	5-29	8.2	13.1	10.4	1.37	100	19	1	--	--	1	5	--		
Rabo de ratón	CA	20	4-12	8.5	18.2	12.2	1.25	100	15	5	--	--	5	25	16.7		
" " "	GU	20	4-12	8.5	16.7	12.2	1.25	100	19	1	--	--	1	5	--		
Roble	CA	20	15-26	6.4	16.5	11.4	1.31	100	20	--	--	--	--	--	--		
" "	GU	20	15-26	7.5	13.6	10.5	1.31	100	20	--	--	--	--	--	--		
Teca	CA	20	2-120	2.1	7.0	4.1	.64	73	3	14	3	--	17	85	12.2		
Tulipán africano	CA	19	1-3	4.6	11.2	9.4	--	--	4	15	--	--	15	79	11.3		
Ucar	CA	20	3-120	1.3	3.4	2.0	.42	35	3	12	5	--	17	85	9.5		
Uvilla	CA	19	4-3	2.8	11.8	5.2	1.42	97	2	14	3	--	17	89	10.6		
Yagrumo macho	CA	19	2-4	8.0	15.7	11.4	1.57	100	4	15	1	--	16	84	10.9		
Zarcilla	CA	20	3-120	1.6	3.3	2.3	--	--	2	16	2	--	18	90	9.5		

^{1/} First number, time in hot bath; second number, time in cold bath.

^{2/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 7.--CONDITION OF ROUND POSTS TREATED BY HOT-AND-COLD BATH USING 50% CREOSOTE AND 50% DIESEL OIL AFTER ABOUT 13 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO. TREATED POSTS INSTALLED IN APRIL 1959.

Species																
	Location	in : ing	test : time ^{1/}	Posts: Treat-	Retention of preservative	penetration of sapwood radius	Average side : Serv- iceable	Condition of posts, April 1972	Removed because of Decay & Termites : termites	Total removed	Average ^{2/} life					
	No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.		
Camasey blanco	CA	20	4-120	3.1	10.6	6.6	.81	59	15	5	--	--	5	25	17.0	
" "	GU	20	4-120	3.2	11.4	7.3	.81	59	14	5	1	--	6	30	16.3	
Casuarina	CA	20	15-24	6.8	11.2	9.0	1.52	100	12	8	--	--	8	40	15.0	
" "	GU	20	15-24	7.2	10.9	9.0	1.52	100	18	2	--	--	2	10	20.3	
Guaba	CA	20	3-8.5	5.8	14.0	10.1	1.06	74	19	1	--	--	1	5	--	
" "	GU	20	3-8.5	3.7	12.8	8.5	1.06	74	18	2	--	--	2	10	20.3	
Guamá	CA	20	3-28	2.8	11.5	7.0	1.25	86	20	--	--	--	--	--	--	
" "	GU	20	3-28	3.7	12.1	7.4	1.25	86	20	--	--	--	--	--	--	
Hoja menuda	CA	20	4-120	5.3	8.6	6.6	1.44	98	17	3	--	--	3	15	18.6	
" "	GU	20	4-120	6.3	8.9	7.6	1.44	98	19	1	--	--	1	5	--	
Laurel geo	CA	21	3-2	3.2	16.1	9.2	1.01	82	18	3	--	--	3	14	19.0	
" "	GU	20	3-2	2.9	15.8	9.3	1.01	82	16	4	--	--	4	20	17.6	
Mangle blanco	CA	20	15-120	3.1	13.8	5.4	.98	100	12	5	3	--	8	40	15.0	
" "	GU	20	15-120	3.1	9.6	5.4	.98	100	16	4	--	--	4	20	17.6	
Pomarrosa	CA	20	3-20	9.1	15.1	11.8	1.41	100	15	5	--	--	5	25	17.0	
" "	GU	19	3-20	9.2	13.3	11.0	1.41	100	18	1	--	--	1	5	--	
Rabo de ratón	CA	19	3-2	8.7	15.7	11.7	1.36	100	19	--	--	--	--	--	--	
" " "	GU	21	3-2	10.0	16.1	13.1	1.36	100	20	1	--	--	1	5	--	
Roble	CA	20	3-4.5	3.9	12.8	7.6	.96	66	20	--	--	--	--	--	--	
" "	GU	20	3-4.5	3.9	10.5	6.6	.96	66	19	1	--	--	1	5	--	

^{1/} First number, time in hot bath; second number, time in cold bath.

^{2/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 8.--CONDITION OF ROUND POSTS TREATED BY HOT-AND-COLD BATH USING CARBOLINEUM. TORO NEGRO AND CAMBALACHE POSTS IN SERVICE 22 YEARS; EL VERDE POSTS IN SERVICE 28 YEARS.

Species																
	Location	in : ing	test : time ^{1/}	Posts: Treat-	Retention of preservative	penetration of sapwood radius	Average side : Serv- iceable	Condition of posts, April 1972	Removed because of Decay & Termites : termites	Total removed	Average ^{2/} life					
	No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	No.	Pct.	Yr.	
Casuarina	El Verde	6	6-16	17	23	20	3/4-1	30	5	1	--	--	1	17	38.0	
Caimitillo	Cambalache	2	4-16	5.3	5.5	5.4	Irregular		2	--	--	--	--	--	--	
" "	Toro Negro	2	4-16	5.5	7.0	6.2	"		2	--	--	--	--	--	--	
Eucalipto (patentinervis)	Cambalache	2	4-16	8.0	10.5	9.2	"		2	--	--	--	--	--	--	
" "	Toro Negro	1	4-16	5.1	5.4	5.2	"		1	--	--	--	--	--	--	
Eucalipto (robusta)	Cambalache	12	4-16	2.6	9.8	6.0	"		12	--	--	--	--	--	--	
" "	Toro Negro	9	4-16	4.4	7.8	6.0	"		9	--	--	--	--	--	--	

^{1/} First number, time in hot bath; second number, time in cold bath.

^{2/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 9.--CONDITION OF ROUND POSTS TREATED BY DOUBLE DIFFUSION AFTER 12 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO. POSTS INSTALLED IN MARCH 1960.

Species																			
	Treatment	Time	Test	Locality	Posts	Retention	Barrel	Tank	penetration	Servable	Removed because of	Decay & Termites	Mites	Total removed	Average life				
									(T-CAC)										
										No.	No.	No.	No.	No.	Pct.				
										Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	No.	No.	No.	No.	Yr.
Achiotillo	CA	T-FC ^{3/}	3+3	18					.41		10	7	1	--	8	44	13.3		
	CA	T-CAC ^{4/}	2+2	20					.80	G	5	8	7	--	15	75	10.5		
	CA	B-CAC ^{5/}	2+2	10	1.06	trace					--	6	2	2	10	100	4.6		
	CA	B-FC ^{6/}	3+3	9	.69	.03					--	2	5	2	9	100	4.0		
Almácigo	CA	T-FC	3+3	15					.43		--	14	1	--	15	100	6.5		
	CA	T-CAC	2+2	20					.89	G	3	16	--	1	17	85	6.7		
	CA	B-CAC	2+2	9	1.50	.03					--	4	1	4	9	100	5.7		
	CA	B-FC	3+3	8	.57	.02					--	8	--	--	8	100	1.5		
Almendra	CA	T-FC	4+4	18					.50		4	5	9	--	14	78	8.3		
	CA	T-CAC	2+2	17					1.44	G	4	12	1	--	13	77	10.4		
	CA	B-CAC	2+2	3	4.33	.02					--	3	--	--	3	100	6.8		
	CA	B-FC	4+4	6	.85	.05					--	5	1	--	6	100	6.0		
Bambú (retention based on volume of wall only)	CA	T-FC	3+3	20					.32		--	20	--	--	20	100	2.2		
	GU	T-FC	3+3	18					.32		--	18	--	--	18	100	5.3		
	CA	T-CAC	2+2	19					1.17	P	--	19	--	--	19	100	3.6		
	GU	T-CAC	2+2	22					1.17	P	--	22	--	--	22	100	7.5		
	CA	B-CAC	2+2	10	1.48	.03					--	10	--	--	10	100	2.1		
	CA	B-FC	3+3	8	.69	.06					--	6	1	1	8	100	2.0		
Cacao motillo	CA	T-FC	2+4	19					.22		11	8	--	--	8	42	13.3		
	CA	T-CAC	2+2	20					.63	F	12	8	--	--	8	40	13.8		
	CA	B-CAC	2+2	10	1.07	.02					--	1	--	9	10	100	6.1		
	CA	B-FC	2+4	10	.72	.01					--	2	--	8	10	100	6.9		
Caimitillo	CA	T-FC	3+3	19					.27		10	8	1	--	9	47	13.0		
	CA	T-CAC	2+2	20					.28	P	19	1	--	--	1	5	--		
	CA	B-CAC	2+2	10	1.39	.01					1	--	--	9	9	90	10.3		
	CA	B-FC	3+3	11	.46	.06					3	5	--	3	8	73	11.0		
Camasey blanco	CA	T-FC	3+3	21					.56		3	16	2	--	18	85	8.2		
	CA	T-CAC	2+2	19					1.29	C	6	12	1	--	13	68	11.6		
	CA	B-CAC	2+2	9	1.20	.04					1	8	--	--	8	90	7.3		
	CA	B-FC	3+3	10	.60	.03					1	6	3	--	9	90	9.0		
Caoba dominicana	CA	T-FC	3+3	19					.32		12	6	1	--	7	37	13.8		
	CA	B-FC	3+3	7	.55	.03					--	7	--	--	7	100	7.5		
Cassia de Siam	CA	T-CAC	2+2	20					.41	G	18	2	--	--	2	10	18.5		
	CA	B-CAC	2+2	10	1.41	.02					--	3	1	6	10	100	11.6		
Casuarina	CA	T-FC	3+3	19					.19		--	15	4	--	19	100	6.1		
	GU	T-FC	3+3	20					.19		1	15	4	--	19	95	8.3		
	CA	T-CAC	2+2	19					.60	P	5	14	--	--	14	74	10.0		
	GU	T-CAC	2+2	20					.60	P	9	11	--	--	11	55	12.5		
	CA	B-CAC	2+2	11	1.42	.01					--	5	--	6	11	100	6.8		
	CA	B-FC	3+3	9	.99	.05					--	5	2	2	9	100	8.0		
Eucalipto (robusta)	CA	T-FC	3+3	17					.60		7	10	--	--	10	59	12.2		
	CA	T-CAC	2+2	22					.81	G	10	12	--	--	12	55	12.7		
	CA	B-CAC	2+2	10	1.18	.06					--	8	--	2	10	100	10.0		
	CA	B-FC	3+3	10	.99	.05					--	4	1	5	10	100	6.0		
Guaba	CA	T-FC	3+3	20					.26		9	11	--	--	11	55	12.6		
	CA	T-CAC	2+2	20					.53	G	16	4	--	--	4	20	16.0		
	CA	B-CAC	2+2	10	1.60	.01					--	4	1	5	10	100	10.5		
	CA	B-FC	3+3	9	.52	.04					--	7	--	2	9	100	10.3		
Guamá	CA	T-FC	3+3	19					.16		--	17	2	--	19	100	7.9		
	GU	T-FC	3+3	20					.16		8	12	--	--	12	60	12.0		
	CA	T-CAC	2+2	20					.43	P	12	8	--	--	8	40	13.7		
	GU	T-CAC	2+2	20					.43	P	12	8	--	--	8	40	13.7		
	CA	B-CAC	2+2	10	.90	.06					6	3	--	1	4	40	13.7		
	CA	B-FC	3+3	12	.39	.05					--	7	2	3	12	100	7.8		
Hoja menuda	CA	T-FC	3+3	20					.16		--	18	2	--	20	100	7.3		
	CA	T-CAC	2+2	19					.48	F	10	9	--	--	9	47	12.8		
	CA	B-CAC	2+2	9	1.44	.02					--	4	3	--	5	55	12.7		
	CA	B-FC	3+3	9	.37	.04					--	2	2	--	9	100	7.2		

^{1/} C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch.

^{2/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.

^{3/} T-FC: Tank treatment - 4 percent NaF and 7 percent CuSO₄.

^{4/} T-CAC: Tank treatment - 10 percent CuSO₄ and 6 1/2 percent Na₂CrO₄ + 6 1/2 percent Na₂HasO₄.

^{5/} B-CAC: Posts upright in barrels (butt only) - 10 percent CuSO₄ and 6 1/2 percent Na₂CrO₄ + 6 1/2 percent Na₂HasO₄.

^{6/} B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent CuSO₄.

Table 9.--CONDITION OF ROUND POSTS TREATED BY DOUBLE DIFFUSION AFTER 12 YEARS OF SERVICE. CAMBALACHE (CA) AND GUAVATE (GU) TEST PLOTS, PUERTO RICO. POSTS INSTALLED IN MARCH 1960. (CONTINUED)

Species	Loca-	Treat-	Treat-	Posts	Retention			Radial ^{1/} penetration	Condition of posts, April 1972			Total removed	Average ^{2/} life			
					tion	ment	ing		by tank	Serv-	Removed because of					
					time	test	Ground	Top	average	iceable	Decay	Decay &	Ter-			
							line	:	treatment	:	termites	mites	:			
								(T-CAC)								
					Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	No.	No.	No.	No.	Pct.	Yr.	
Laurel avispillo	CA	T-FC ^{3/}	3+3	20				.31		5	11	4	--	15	75	10.7
	CA	T-CAC ^{4/}	2+2	20				1.24	F	11	8	1	--	9	45	13.3
	CA	B-CAC ^{5/}	2+2	10	1.52	.04			--	5	--	5	10	100	5.7	
	CA	B-FC ^{6/}	3+3	11	.58	.09			--	3	3	5	11	100	5.6	
Laurel geo	CA	T-FC	3+3	19			.24			8	11	--	--	11	58	12.2
	GU	T-FC	3+3	20			.24			12	8	--	--	8	40	13.7
	CA	T-CAC	2+2	19			.73	C	13	6	--	--	6	32	14.7	
	GU	T-CAC	2+2	20			.73	C	14	6	--	--	6	30	15.0	
	CA	B-CAC	2+2	10	2.02	.07				3	6	--	1	7	70	11.0
	CA	B-FC	3+3	9	.91	.05			--	8	1	--	9	100	6.8	
Mangle blanco	CA	T-FC	3+3	19			.07		--	9	10	--	19	100	7.3	
	GU	T-FC	3+3	20			.07		6	13	1	--	14	70	11.5	
	CA	T-CAC	2+2	19			.62	P	12	4	2	1	7	37	14.0	
	GU	T-CAC	2+2	20			.62	P	14	3	2	1	6	30	15.0	
	CA	B-CAC	2+2	11	.85	.01			--	3	2	6	11	100	3.9	
	CA	B-FC	3+3	8	.13	.02			--	4	2	2	8	100	5.8	
Mantequero	CA	T-FC	3+3	20			.30		--	18	2	--	20	100	7.9	
	CA	T-CAC	2+2	18			.76	P	1	16	1	--	17	94	8.4	
	CA	B-CAC	2+2	9	1.36	.02			--	3	--	6	9	100	6.1	
	CA	B-FC	3+3	9	.56	.03			--	3	1	5	9	100	6.1	
María	CA	T-FC	3+3	19			.32		F	2	16	1	--	17	90	8.9
	CA	T-CAC	2+2	19			.45			10	9	--	9	47	12.8	
	CA	B-CAC	2+2	10	.93	.05				3	3	--	4	7	70	11.4
Pomarrosa	CA	T-FC	3+3	20			.29			--	19	1	--	20	100	7.2
	CA	T-CAC	2+2	20			.59	F		--	19	1	--	20	100	7.0
	CA	B-CAC	2+2	10	1.79	.02				1	1	--	8	9	90	6.1
	CA	B-FC	3+3	9	.65	.02			--	3	1	5	9	100	5.7	
Rabo de ratón	CA	T-FC	3+3	19			.20			1	13	5	--	18	95	8.5
	CA	T-CAC	2+2	20			.89	F		4	16	--	--	16	80	9.0
	CA	B-CAC	2+2	10	1.26	.02				1	7	1	1	9	90	8.6
	CA	B-FC	3+3	10	.55	.04			--	2	3	5	10	100	6.0	
Retama	CA	T-FC	2+4	20			.33			2	18	--	--	18	90	10.0
	CA	T-CAC	2+2	20			.48	P		16	4	--	4	20	16.0	
	CA	B-CAC	2+2	10	.83	.02				5	5	--	5	50	12.7	
	CA	B-FC	2+4	9	.86	.10			--	3	4	2	9	100	8.0	
Roble	CA	T-FC	3+3	19			.29			17	2	--	2	11	18.3	
	GU	T-FC	3+3	20			.29			18	2	--	2	10	18.4	
	CA	T-CAC	2+2	20			.53	F		19	1	--	1	5	--	
	GU	T-CAC	2+2	20			.53	F		20	--	--	--	--	--	
	CA	B-CAC	2+2	9	2.28	.05				1	8	--	8	89	8.7	
	CA	B-FC	3+3	10	.97	.09			--	10	--	--	10	100	7.3	
Teca	CA	T-FC	3+3	20			.58		G	9	11	--	--	11	55	12.7
	CA	T-CAC	2+2	20			1.02			15	5	--	5	25	14.3	
	CA	B-CAC	2+2	11	1.70	.06				5	4	--	2	6	55	12.7
	CA	B-FC	3+3	8	.77	.03			--	8	--	--	8	100	8.2	
Tulipán africano	CA	T-FC	4+4	15			.53			14	--	1	15	100	6.4	
	CA	T-CAC	2+2	20			1.24	C		8	5	2	12	60	11.0	
	CA	B-CAC	2+2	7	1.90	.12				6	--	1	7	100	7.6	
	CA	B-FC	4+4	6	.83	.05			--	6	--	--	6	100	7.1	
Uvilla	CA	T-FC	3+3	20			.43			20	--	--	20	100	6.0	
	CA	T-CAC	2+2	21			.56	F		21	--	--	21	100	6.8	
	CA	B-CAC	2+2	8	.93	.02				1	6	--	1	7	88	8.2
	CA	B-FC	3+3	9	.58	.03			--	8	--	1	9	100	6.7	
Verde seco	CA	T-FC	2+4	20			.45			13	7	--	7	35	14.1	
	CA	T-CAC	2+2	20			.61	C		15	5	--	5	25	14.3	
	CA	B-CAC	2+2	10	1.30	.02				10	--	--	--	--	--	
	CA	B-FC	2+4	10	.64	.03				2	7	--	1	8	80	9.6
Yagrumo hembra	CA	T-FC	3+3	17			.42		G	3	12	1	1	14	82	8.9
	CA	T-CAC	2+2	20			.87			7	12	1	--	13	65	9.0
	CA	B-CAC	2+2	8	.69	.02				8	--	--	8	100	5.8	
	CA	B-FC	3+3	6	.79	.03			--	4	1	1	6	100	2.1	
Yagrumo macho	CA	T-FC	2+4	16			.47			2	13	1	--	14	87	9.0
	CA	T-CAC	2+2	19			1.10	C		1	18	--	--	18	95	8.6
	CA	B-CAC	2+2	9	1.41	.03				6	--	3	9	100	6.1	
	CA	B-FC	2+4	10	.65	.02			--	7	1	2	10	100	2.2	
Zarcilla	CA	T-FC	3+3	21			.34			21	--	--	21	100	7.3	
	CA	T-CAC	2+2	20			.75	F		5	15	--	15	75	8.6	
	CA	B-CAC	2+2	10	1.04	.01				2	4	4	10	100	6.1	
	CA	B-FC	3+3	10	.53	.08			--	4	3	3	10	100	3.7	

^{1/} C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch.

^{2/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.

^{3/} T-FC: Tank treatment - 4 percent NaF and 7 percent CuSO₄.

^{4/} T-CAC: Tank treatment - 10 percent CuSO₄ and 6 1/2 percent Na₂CrO₄ + 6 1/2 percent Na₂HAsO₄.

^{5/} B-CAC: Posts upright in barrels (butt only) - 10 percent CuSO₄ and 6 1/2 percent Na₂CrO₄ + 6 1/2 percent Na₂HAsO₄.

^{6/} B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent CuSO₄.

Table 10.--CONDITION OF INCISED AND NON-INCISED POSTS TREATED BY A 2 HR.-2 HR. HOT-AND-COLD BATH USING 5% PENTACHLOROPHENOL DISSOLVED IN DIESEL OIL AFTER 5 YEARS OF SERVICE. CAMBALACHE TEST PLOT, PUERTO RICO. POSTS INSTALLED IN APRIL 1967.

Species and incising treatment	Posts in test			Retention of preservative		Average side penetration of sapwood radius		Condition of posts, April 1972				Total removed		Average 1/ life		
	No.	Lb.per cu.ft.	Lb.per cu.ft.	Min.	Max.	Av.	With incising	Without incising	Servicable	Removed because of Decay & Termites	No.	No.	No.	No.	No. Pct.	Yr.
							In. Pct.	In. Pct.	No.	No.	No.	No.	No.	No.		
Cacao motillo							1.1	88	.6	47						
none	10	6.3	10.8	7.7					10	--	--	--	--	--	--	--
groundline only	5	6.8	11.2	8.8					5	--	--	--	--	--	--	--
full length	5	9.5	12.1	10.6					5	--	--	--	--	--	--	--
Cadam							2.0	100	1.3	84						
none	10	18.2	28.7	24.2					10	--	--	--	--	--	--	--
groundline only	5	18.0	27.1	22.6					5	--	--	--	--	--	--	--
full length	5	21.5	29.8	25.2					5	--	--	--	--	--	--	--
Caimitillo (mesa)							1.0	72	.4	28						
none	10	4.9	8.5	6.4					10	--	--	--	--	--	--	--
groundline only	5	5.5	9.9	8.2					5	--	--	--	--	--	--	--
full length	5	6.8	12.0	9.1					5	--	--	--	--	--	--	--
Casuarina							.8	71	.3	23						
none	10	3.3	9.1	5.9					10	--	--	--	--	--	--	--
groundline only	5	6.4	10.9	8.2					5	--	--	--	--	--	--	--
full length	5	7.6	12.4	9.5					5	--	--	--	--	--	--	--
Eucalipto (robusta)							.9	68	.8	66						
none	10	5.9	19.1	11.2					10	--	--	--	--	--	--	--
groundline only	5	5.8	13.8	9.8					5	--	--	--	--	--	--	--
full length	5	11.4	15.9	12.6					5	--	--	--	--	--	--	--
Guaba							.8	52	.3	25						
none	9	2.1	4.2	2.9					9	--	--	--	--	--	--	--
groundline only	5	3.3	5.2	4.1					5	--	--	--	--	--	--	--
full length	5	6.9	8.4	7.4					5	--	--	--	--	--	--	--
Guamá							.8	66	.2	12						
none	10	2.0	5.6	3.2					10	--	--	--	--	--	--	--
groundline only	5	1.9	4.2	3.0					5	--	--	--	--	--	--	--
full length	5	2.8	4.8	3.8					5	--	--	--	--	--	--	--
Hoja menuda							.8	46	.3	17						
none	10	4.5	8.8	6.3					10	--	--	--	--	--	--	--
groundline only	5	4.8	7.3	6.0					5	--	--	--	--	--	--	--
full length	5	6.0	8.3	7.3					5	--	--	--	--	--	--	--
Mangle prieto							.8	53	.3	21						
none	10	2.1	5.0	3.5					10	--	--	--	--	--	--	--
groundline only	5	3.8	5.7	4.8					5	--	--	--	--	--	--	--
full length	4	7.3	9.4	8.1					4	--	--	--	--	--	--	--
María							1.0	70	.5	37						
none	10	4.1	6.7	5.3					10	--	--	--	--	--	--	--
groundline only	5	4.4	7.6	5.9					5	--	--	--	--	--	--	--
full length	5	7.6	11.7	10.0					5	--	--	--	--	--	--	--
Moca							.7	60	.2	17						
none	9	4.3	7.2	5.6					9	--	--	--	--	--	--	--
groundline only	4	4.7	6.1	5.9					4	--	--	--	--	--	--	--
full length	5	4.6	8.8	6.5					5	--	--	--	--	--	--	--
Péndula							.7	50	.1	9						
none	10	1.1	2.9	1.9					10	--	--	--	--	--	--	--
groundline only	5	2.2	4.6	3.3					5	--	--	--	--	--	--	--
full length	5	3.8	5.9	4.7					5	--	--	--	--	--	--	--
Pino							1.6	100	1.5	100						
none	9	23.0	36.0	28.4					9	--	--	--	--	--	--	--
groundline only	3	24.4	29.5	26.6					3	--	--	--	--	--	--	--
full length	5	22.1	27.2	26.6					5	--	--	--	--	--	--	--
Pomarrosa							.8	64	.2	15						
none	9	4.0	7.7	5.4					9	--	--	--	--	--	--	--
groundline only	4	4.4	8.3	6.5					4	--	--	--	--	--	--	--
full length	5	7.5	9.9	8.6					5	--	--	--	--	--	--	--
Rabo de ratón							1.1	84	.3	29						
none	10	4.9	13.4	8.3					10	--	--	--	--	--	--	--
groundline only	5	6.9	12.1	10.1					5	--	--	--	--	--	--	--
full length	5	8.2	10.9	9.4					5	--	--	--	--	--	--	--
Roble blanco							.8	69	.2	17						
none	10	1.5	3.1	2.4					9	1	--	--	1	10	7.7	
groundline only	5	3.2	5.1	3.9					5	--	--	--	--	--	--	--
full length	5	7.7	11.0	9.3					5	--	--	--	--	--	--	--
Teca							.6	65	.4	35						
none	10	2.1	4.2	2.8					10	--	--	--	--	--	--	--
groundline only	5	2.4	3.2	2.7					5	--	--	--	--	--	--	--
full length	5	3.4	5.1	4.0					5	--	--	--	--	--	--	--
Uvilla							.6	56	.1	10						
none	10	.6	2.9	1.5					10	--	--	--	--	--	--	--
groundline only	5	1.3	3.4	2.4					5	--	--	--	--	--	--	--
full length	4	2.7	5.2	3.5					4	--	--	--	--	--	--	--

^{1/} Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

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APPENDIX

List of common and scientific names of species under review in this report.

Abeyuelo	<i>Colubrina arborescens</i> (Mill.) Sarg.
Acacia amarilla	<i>Albizia lebbeck</i> (L.) Benth.
Achiotillo	<i>Alchornea latifolia</i> Sw.
Aguacatillo	<i>Meliosma herbertii</i> Rolfe
Almácigo	<i>Bursera simaruba</i> (L.) Sarg.
Almendra	<i>Terminalia catappa</i> L.
Ausubo	<i>Manilkara bidentata</i> (A.DC.) Chev.
Bambú	<i>Bambusa vulgaris</i> Schrad.
Cacao motillo	<i>Sloanea berteriana</i> Choisy
Cadam (Radam)	<i>Anthocephalus cadamba</i> (Roxb.) Miq.
Caimitillo (mesa)	<i>Micropholis chrysophylloides</i> Pierre
Caimitillo de perro	<i>Chrysophyllum oliviforme</i> L.
Caimitillo verde	<i>Micropholis garcinifolia</i> Pierre
Camasey blanco	<i>Miconia laevigata</i> (L) DC.
Camasey de felpa	<i>Miconia prasina</i> (Sw.) DC.
Camasey jusillo	<i>Calycogonium squamulosum</i> Cogn.
Caoba dominicana	<i>Swietenia mahagoni</i> Jacq.
Caoba hondureña	<i>Swietenia macrophylla</i> King
Capá blanco	<i>Petitia domingensis</i> Jacq.
Caracolillo	<i>Homalium racemosum</i> Jacq.
Cassia de Siam	<i>Cassia siamea</i> Lam.
Casuarina	<i>Casuarina equisetifolia</i> L.
Cieneguillo	<i>Myrcia deflexa</i> (Poir.) DC
Cucubano	<i>Guettarda scabra</i> (L.) Vent.
Espino rubial	<i>Zanthoxylum martinicense</i> (Lam.) DC.
Eucalipto (patentinervis)	<i>Eucalyptus patentinervis</i> R.T. Baker
Eucalipto (robusta)	<i>Eucalyptus robusta</i> J.A. Smith
Granadillo	<i>Buchenavia capitata</i> (Vahl.) Eichl.
Guaba	<i>Inga vera</i> Willd.
Guacimilla	<i>Trema micrantha</i> (L.) Blume
Guamá	<i>Inga laurina</i> (Sw.) Willd.
Guaraguao	<i>Guarea trichilioides</i> L.
Guácima	<i>Guazuma ulmifolia</i> Lam.
Hoja menuda	<i>Myrcia coriacea</i> DC.
Hueso blanco	<i>Linociera domingensis</i> (Lam.) Knobl.
Jagüey	<i>Ficus laevigata</i> Vahl.
Laurel avispillo	<i>Nectandra coriacea</i> (Sw.) Griseb.

Laurel geo	<i>Ocotea leucoxylon</i> (Sw.) Maza
Mangle blanco	<i>Laguncularia racemosa</i> (L.) Gaertn. f.
Mangle botón	<i>Conocarpus erectus</i> L.
Mangle colorado	<i>Rhizophora mangle</i> L.
Mangle prieto	<i>Avicennia nitida</i> Jacq.
Mantequero	<i>Rapanea ferruginea</i> (Ruiz & Pav.) Mez
Manzanillo	<i>Sapium laurocerasus</i> Desf.
María	<i>Calophyllum brasiliense</i> Camb.
Maricao	<i>Byrsonima spicata</i> (Cav.) Rich.
Masa	<i>Tetragastris balsamifera</i> (Sw.) Kuntze
Moca	<i>Andira inermis</i> (W. Wright) H.B.K.
Moral	<i>Cordia sulcata</i> DC
Muñeco	<i>Cordia borinquensis</i> Urban
Negra lora	<i>Matayba domingensis</i> (D.S.) Radlk.
Palo de gallina	<i>Alchorneopsis portoricensis</i> Urban
Palo de matos	<i>Ormosia krugii</i> Urban
Péndula	<i>Citharexylum fruticosum</i> L.
Pino	<i>Pinus caribaea</i> Morelet
Pomarrosa	<i>Eugenia jambos</i> L.
Rabo de ratón	<i>Casearia arborea</i> (L.C. Rich.) Urban
Retama	<i>Sabinea florida</i> (Vahl.) DC.
Roble	<i>Tabebuia heterophylla</i> (DC.) Brit.
Sabinón	<i>Croton poecilanthus</i> Urban
Tabloncillo	<i>Sideroxylon portoricensis</i> Urban
Tabonuco	<i>Dacryodes excelsa</i> Vahl.
Tachuelo	<i>Pictetia aculeata</i> (Vahl.) Urban
Tea	<i>Amyris elemifera</i> L.
Teca	<i>Tectona grandis</i> L. f.
Tortugo amarillo	<i>Sideroxylon foetidissimum</i> Jacq.
Tulipán africano	<i>Spathodea campanulata</i> Beauv.
Ucar	<i>Bucida buceras</i> L.
Uvilla	<i>Coccoloba diversifolia</i> Jacq.
Verde seco	<i>Tetrazygia elaeagnoides</i> (Sw.) DC.
Yagrumo hembra	<i>Cecropia peltata</i> L.
Yagrumo macho	<i>Didymopanax morototoni</i> (Aubl.) Dec. & Pl.
Zarcilla	<i>Leucaena glauca</i> (L.) Benth.

Chudnoff, M. and E. Goytia
1972. Preservative treatments and service life of fence posts in Puerto Rico (1972 Progress Report)
Inst. Trop. Forestry, U. S. Forest Serv. Res. Paper ITF-12.

Posts treated by four non-pressure techniques using five wood preservation chemicals have been set out at four test locations. About 6,700 treated and non-treated control posts representing some 70 species are under study. This report describes materials and methods used, chemical retentions and penetrations obtained, and reviews the condition of the posts up through the April 1972 inspection. Some installations date back to 1944, but most of the test posts have been in service for 13 years or less. Vertical cold-soaking and the hot-and-cold bath technique are most effective and should be preferred over conventional cold soaking or salt combinations applied by double diffusion.

O.D.C. 841.42

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Laurel ge
Mangle bl
Mangle bc
Mangle cc
Mangle pr
Mantequer
Manzanillc
María
Maricao
Masa
Moca
Moral
Muñeco
Negra lora
Palo de g.
Palo de n
Péndula
Pino
Pomarrosa
Rabo de
Retama
Roble
Sabinón
Tabloncillo
Tabonuco
Tachuelo
Tea
Teca
Tortugo a
Tulipán al
Ucar
Uvilla
Verde sec
Yagrumo
Yagrumo
Zarcilla

